Do established companies and academic spin-off companies need different capabilities for technology development process? A discussion based upon literature models available

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Abstract: This work uses an evolutionary approach to organizational studies to make a comparison between the technology development in established companies and in academic spin-off companies. The objective is to analyze the following question: Do established companies and academic spin-off companies need different capabilities for technology development process? The several literature documents available were used as secondary evidence source. Both types of companies appear to be discussed independently, with different approaches. The conducted comparison was based on the list of document attributes including main discussed themes. These themes were considered as indicatives of capabilities suggestions to be developed in each type of company or in their development stages. The documents were evaluated on the presence or absence of attributes and they were grouped using binary cluster analysis. Based on cluster analysis results, a descriptive model of new technology based company's capabilities development path was elaborated with evolutionary organizations logic view. It was demonstrated that, especially when the technology is highly innovative, the idea of capability development and business model construction is detached, both in spin-off and established companies.

Keywords: technology development process, academic spin-off development, new product development process management, RBV, capabilities.

1. Introduction

The radically new technological knowledge starts from a research, usually inside a research institution (SHANE, 2004; LEE; GAERTNER, 1994; IANSITI, 1995). Nevertheless, the technological knowledge is not ready for conversion to product or service; it must be transferred to a commercial environment (company) for further development (SHANE, 2004; AUTIO, 1994). The initial research phase's element (technology) focus is replaced by the system (components, subsystems, systems, process, market, use) focus. New elements are continuously incorporated from the prototype testing to achieve different proprieties and to develop additional fabrication process. Important proprieties are related to achieve adaptation to application area and usability (SHANE, 2004; IANSITI, 1995; LEE; GAERTNER, 1994; BURGELMAN; SAYLES, 2004).

In another approach, they are observed several works presenting discussion about capabilities and routine development, and subsequent business model evolution (ANDRIES; DEBACKERE, 2006; DRUILHE; GARNSEY, 2004; BURGELMAN; SAYLES, 2004; CHESBROUGH; ROSENBLOON, 2002; MORRIS; SCHINDEHUTTE; ALLEN, 2005). This work understands capability as abilities converted to repetitive pattern of activities (routines) with defined input and outputs that enable the managers a conjoint of options to take decision to make significant outputs. The capabilities are comprised by routines to execute the individual tasks and routines for routine coordination (HELFAT; PETERAF, 2003; NELSON; WINTER, 1982). These capabilities start and mature with the repetition, comprising the capability lifecycle. Inside the company, the selection of the capabilities and the dispute for existing resources happens (HELFAT; PETERAF, 2003; KAZANJIAN; RAO, 1999; ZAHRA; SAPIENZA; DAVIDSON, 2006).

The information inputs for capabilities development come from environment. Based on those inputs, the company must create standards for the product, services

and process to enable the manufacturing and distribution to the final user. Those standards will be implemented as routines that configure the business model (VOHORA; WRIGHT; LOCKETT, 2004; ALDRICH; RUEF, 2006). This discussion is inspired on evolutionary approach (NELSON; WINTER, 1982; STOELHORST, 2008; MATHEWS, 2006; ALDRICH; RUEF, 2006; DURAND, 2006). Similar approaches of business model evolution were observed in technology and product development process in established companies (BURGELMAN; CHRISTENSEN; WHEELWRIGHT, 2004) and also in corporative and academic spin-off related documents (DRUILHE; GARNSEY, 2004; VOHORA; WRIGHT; LOCKETT, 2004).

The evolutionary approach of organizations enables the study of variation and selection processes in new organizations (ALDRICH; RUEF, 2006). Considering this, it is used for study spin-off companies development and technology and product development because this approach studies the company's growth (BARNEY, 2001; PRAHALAD; HAMEL, 1990; HELFAT; PETERAF, 2003; NELSON; WINTER, 1982; TEECE; PISANO; SHUEN, 1997; ZAHRA; SAPIENZA; DAVIDSON, 2006; WINTER, 2003; STOELHORST, 2008; MATHEWS, 2006; ALDRICH; RUEF, 2006; DURAND, 2006).

Utterback (1994) presents the evolution of change's type that occurs inside the company, especially those that starts from invention or technology. Initially, until design is defined, mainly radical and product innovation occurs. This is followed by process innovation. After this, the both process and product innovation type of occur slowly and just incremental innovation occurs until new radical product innovation (UTTERBACK, 1994). Then, the routines (and consequently capabilities) must evolve inside the company (GRANT, 1996; HELFAT; PETERAF, 2003; NELSON; WINTER, 2005; ZAHRA; SAPIENZA; DAVIDSON, 2006).

The both types of companies, established technology-based companies and new technology-ventures including academic spin-offs, appear to be discussed independently by different approaches. This work understands the academic spin-off discussion as related to the company's development and the technology development inside this company. So, the objective is to analyze the question 'do the established companies and academic spin-off companies need different capabilities for technology development process?'. This work uses as evidence source the literature available models for technology development. The intention was to compare the main feature or contents and focus-related specificities on the models. Hence, the literature discussed main features and contents were used as indicative of capabilities. The capabilities are understood as the abilities (possibly implemented as routines inside the company) discussed by literature as necessary for company's growth, technology development, and commercially viable products and services.

2. Method and data collection

This paper conducts a descriptive, qualitative and theoretical research, comprised by literature review followed by content analysis (KRIPPENDORF, 1980).

Initially, the literature was analyzed for specificities identification in technology development, transference and conversion to commercially viable services and products. Following, it was joined from literature several documents describing technology development process. Evaluating these documents, it was created a database presenting the document attributes. The document attributes were grouped by similarity. From this, it was able to evaluate the specificities and commonalities in Technology development in academic spin-off companies, new technology based ventures and established companies.

3. Literature review and differences search

A clear difference between technology development in an established technology based companies and in a new technology venture initiated as academic spin-off can be the starting context and environment. The established company usually have well-defined strategy and target-market. So, it starts from the development or search for acquisition of the technology using these definitions and with evaluation of cost-benefit (CREVELING; SLUTSKY; ANTIS, 2003; BURGELMAN; CHRISTENSEN; WHEELWRIGHT, 2004). This previous market and application definition can originate the omission of other potential markets and applications. Some documents present situations in which the established company develop and evaluate different application options (BURGELMAN; CHRISTENSEN; WHEELWRIGHT, 2004).

However one significant difference emphasized by the literature is the technology type and innovativeness. In existing companies, the technology development is usually more specific, not originating so radical innovation. Academic spin-off can be originated using and spotlighting an academic research-resulting invention, and usually can be composed by academic research experienced persons. Thus, this kind of company can understand and use more effectively the new knowledge generated from applied and basic research, having more potential for develop radical innovation. This is the notorious advantage of generating this kind of company as mechanism of technology transference from the universities. Spin-off creation can be an alternative to develop technologies so radically new that no existing company can visualize an application to be developed (SHANE, 2004; RADOSEVICH, 1995; QUIRK, 2005; THORBURN, 2000; MARKMAN, et al., 2005).

The product development processes in the academic and the corporative environment are different (GOLISH; BESTERFIELD-SACRE; SHUMAN, 2008). Inside the academic spin-off, the product development process happens with similar activities and phases to the traditional new product development process. However, it happens simpler, with fewer activities occurring simultaneously. The phase's transitions are fuzzier, with overlapped phases. Some structures oriented by concurrent engineering and integrated product development philosophies, as highly integrated multidisciplinary project team, can be observed (GOLISH; BESTERFIELD-SACRE; SHUMAN, 2008; MUEGGE; SHARMA; KUMAR, 2005).

Formal practices related to coordination, control and planning are not usually present in academic spin-offs. Muegge, Sharma and Kumar (2005) describe that successful academic inventors (results in registering of patents), conduct activities related to those practices: marketing growth potential definition; planned x executed cost evaluation; marketing requisites definition; and unstable customer needs evaluation.

There were observed decision-taking and process control method just for established companies. Nevertheless, it was discussed that uncertainties and risk are more present in new technology-based companies. Existing methods, as Technology stage-gates and capability maturity model needs complementarities to become fitted for academic spin-off company's reality. Hence, it seems that yet is needed a more suitable tools for these companies.

3.1. Spin-off development

Especially until the first product achievement, the product development process is intrinsically attached to the funding process. The product development milestones, if present in academic spin-off companies, usually have technical and financial focus. The gates occur just if imposed by the environment, customer or investor (GOLISH; BESTERFIELD-SACRE; SHUMAN, 2008; MUEGGE; SHARMA; KUMAR, 2005).

The theme investor attraction is also present in established company. The paper of Markhan (2002) describes that a champion (inventor) needs to convince the company about the potentiality and the importance of the invention to obtain development resources.

The central theme of spin-off development models is related to technology. The indicated by conducted analysis can be confirmed by the literature. Cooper (2006) emphasizes that managing technology development is different from managing incremental product development and that they must be conducted differently. This document denominates technology development the stage comprised by the conversion of an invention (resultant from an applied research) to a new knowledge, new technology, a technical capability or a technological platform (COOPER, 2006; BURGELMAN; SAYLES, 2004). This stage is comprised by the process of creation, selection and refining of technological possibilities, technology integration process (IANSITI, 1995).

In the spin-off company, the spin-off creation and development are puzzled with the technology development inside it. This puzzlement occurs because the company needs to develop new routines (capabilities) to define and develop technological knowledge converting it in an applied technology with a defined application. It was observed that documents presented two spin-off trajectories: the spin-off company creation, and its development (SHANE, 2004; THORBURN, 2000).

It was observed that the institutional and regional innovation system is one of the conductors of this process. However there are yet developing countries that there is neither favourable environment, nor Research Institutions with structured institutional innovation system. In these countries, the discussion must not be just focused on the creation but also on the efforts to develop the spin-off companies. And the process must be conducted by company's own team. It can be assumed that, for this reason, the documents describing both new companies' and spin-off companies' development phases and technology development describes the process as conducted by own company (SHANE, 2004; VOHORA; WRIGHT; LOCKETT, 2004; ZAHRA; DeVELDE; LARRAÑETA, 2007).

4. Literature available models characterization

They were evaluated the technology-based companies' development related literature with focus both on academic spin-off and on established companies. The intention was to compare the main contents and focus-related specificities on the documents. To conducting a comparison, a table with the main attributes of each document was elaborated. This comparative table was analyzed to understand the state-of-the-art panorama related to academic spin-off development and resources and capabilities development. The specific objective is to demonstrate the existence of difference between the conduction of technology development process in established companies and in new technology-based companies, with emphasis on academic spin-off companies.

4.1. Main discussed content identification

For main discussed feature or content identification, the academic search tool scholar google was used to identify publications with key-words 'academic spin-off' or 'academic start-up', and, complementally, 'technology development'. The search was conducted from August 2007 to July 2008. From the identified documents related to academic spin-off, it was selected 85 documents that denote

some preoccupation with academic spin-off management and performance. The publication types as case study and national panorama descriptions were avoided. The publications were comprised by documents from access-available databases, with thesis, dissertations, and papers from scientific journals. The sample was composed by papers from scientific periodic, papers available in web (in University, Research Institute or other relevant agent institutional site), proceedings of congress or conference, doctorate theses and book chapter. A filtering was conducted to identify documents describing the technology development and commercialization development process in established companies and academic spin-off.

There was no intention to exhaust the literature on both academic spin-off-related and not-related technology development documents. Those documents were identified just for reference and comparing purposes. The analyzed documents do not just presented models with detailed description of activities and illustrations/representations. Some documents were incorporated even they do not presented phases description or representation. It was considered that they contributed to technology development description, presenting complementarities to previously identified models.

4.1.1. Criteria definition

This work intended to evaluate the association between the environment focused by the documents (mainly established companies versus new venture including academic spin-off), and the content discussed (indicatives for needed capabilities). Other documents attributes can complement this discussion. For this reason, more than the possible capabilities identification and its association with the environment focused, it was also evaluated the supposed managers, the models purpose and the presentation type. So, the documents were evaluated and compared in basis of following criteria: (i) model presentation type; (ii) model purpose; (iii) discussion focus; and (iv) content. Those criteria are unfolded as attributes, and are described in following, in the Table 1.

For identification of content attributes, it was conducted an effort to elaborate a listing of main contents discussed, an indicative of technology development enabling capabilities to be developed by the company, based on the analyzed literature. The list presents no worry about the moment of the specific capability development. Therefore, the resultant list presents capabilities that the company must develop until fully established, to obtain commercially viable products and services. Those capabilities can be formal or informal. The capabilities were converted to attribute for following analysis.

4.2. Attributes simultaneous occurrence identification

Following, the binary variables were used to conduct the cluster analysis. This analysis enables the identification of a natural structure among the observations. Usually, it enables the grouping of objects, using cluster variate, defined as set of variables that describes and enables objects comparing (HAIR et al., 1998).

In this work, the cluster analysis was used to evaluate simultaneous occurrence of the document's attributes. The high incidence of simultaneous occurrence in several documents gives high similarity measurement, being grouped during the analysis. So, the attributes were considered objects for clustering, and the documents were considered cluster variate.

4.2.1. Sampling and database planning

The selection of the variables constrains the cluster analysis results (HAIR et al., 1998). So, one risk was the existence of bias related to the selection of the database comprising documents. This bias was carefully avoided by some methodological considerations.

In the context of this work, the sampling was not intended to represent the population of documents available in the literature. For this reason, this work did not searched to conduct a representative sampling; instead, the proportion of the documents in the each focus type did not reflect

Table 1. Criteria Groups.

Criteria Group	Attribute	
Focus	a) the process stage;	i) research; ii) technology transfer; iii) product development; and iv) new venture development, without distinguishing if are spin-off or are not
	b) the definition of who conduct or manage the process; and	i) managed by technology transferring office/institution; ii) managed by company's team; and iii) managed by the country.
	c) if describes the academic spin-off company	i) technology development in established company; ii) spin-off company creation; iii) spin-off company development; and iv) product development in spin-off company
Purpose	i) presents process description; ii) just present some important feature discussion; iii) presents how-to instructions; iv) presents method for process control; and v) presents decision-taking methods.	
Presentation type	i) presents phase description; and ii) presents phases representation	
Content	Discussion contents (capabilities)	

intentionally the proportion seen in the state of the art. The purpose was to select and detach the distinguishing documents attributes (discussed content, focus, purpose, model description level), grouping the attributes. So, deliberately, it was planned a proportion that did not enabled a larger quantity of some specific models that should impact on the analysis. The documents were included in the database just if has some mention to the technology development process and if presented in the representative manner the attributes of the population of its document's focus type. So, from 85 spin-off related documents, it was selected 13 documents for sample composition. For complementation of the sample, another 12 documents not related to spin-off company development were added.

The documents were codified for the presence or absence of attributes. Using the list of identified attributes, the documents were analyzed to evaluate the presence of the multistate attribute, using binary variable. The attribute presence was indicated by (1); and the absence, by the (0).

4.2.2. Some results from data base description

The analyzed documents were comprised by some documents presenting 'how to' type descriptions on specific themes, and several documents presenting descriptions of phases and activities, or illustrative representation. The summarizing descriptions of data base are presented as follow, regarding documents' purpose, detail level, documents focus and discussed contents.

The Table 2 presents the document's codification results in the relation to the purpose and focus' related attributes presence.

The main discussed contents were listed in the Table 3. This table also presents frequencies.

4.2.3. Attributes simultaneous occurrence - clustering

The similarity measure used in Cluster Analysis was the Jaccard Coefficient, also named similarity ratio, a commonly recommended measure for binary data. This coefficient ignores 0-0 matches, excluding from consideration joint absences. So, when there are no 1-1 matches, it is considered as maximum dissimilarity. It is much recommended in this situation because joint lack of contents should not be allowed to contribute to their similarity (ROMESBURG, 2004; SSPC Inc., 1997).

In cluster analysis, as connection method, the Between-Groups Linkage or UPGMA linkage (Unweighted Pair-Group Method using Averages) was used. This method was used because considerate information about all inter-cluster pairs, (ROMESBURG, 2004; HAIR, et al., 1998).

For group number definition, it was analyzed in successive steps the measure of group similarity. The definition point was identified as significant increase in the similarity measure progression (HAIR, et al., 1998). There was no so significant increase observed in the similarity measure progression, as confirmed by the dendogram presented in the Figure 1. The authors decided to consider satisfactory 7 clusters with some subgroups. Thus, for further analysis, some the grouping pattern for more than seven clusters described by dendogram was also evaluated. The resultant clusters were described and evaluated. This description enabled to identify some groups of document's attributes that most frequently appeared in conjoint.

For description purpose, it is detached in the Figure 1 the clustering pattern from the end (right side of the figure), pointed by single algorism. As shown in the first level (right), the attribute 'purpose on the description of process control method' was the most different, being grouped for last (1). The farthest group after this attribute was named technological development environment (2). This group indicates that the capabilities for technological development of customers and suppliers are commonly discussed in the national or country level, as Managed by the country (State), by Public Policies. The representative document was Bell and Pavitt (1995), describing Technological Capabilities in the National level.

In the point three (3), it is possible to observe that other groups are very closer than the last two groups. Analyzing in

Table 2. Documents' codification results

Documents' Purpose-Related Attributes	%	Documents Focus-Related Attributes	%
Process description	76%	Managed by company's team	64%
A feature description	36%	Technology transfer	44%
How-to instructions	20%	Spin-off company creation	40%
Decision taking method	16%	Technology development in established company	32%
Process control method	4%	Managed by technology transferring office/ institution	24%
-		New venture development	20%
		Product development	12%
		Spin-off company development	12%
		Product development in spin-off company	8%
		Managed by the country	4%

Table 3. Main discussed contents summary.

Attributes	%
Interaction with customers for product/technology development	52%
Anticipation of impediments and facilitators for business innovation strategy	52%
Interaction with the environment	48%
Entrepreneur team difficulties - managerial questions	48%
Obtain investments	48%
Corporative entrepreneurship management	48%
Conduction of technical product development (prototype development)	44%
Interaction with the research institution	40%
Management of knowledge integration	40%
Management of investments	40%
Entrepreneurial attitude	40%
Evaluation and management of uncertainties and risks	40%
Conversion of prototype to commercial product	40%
Management of product and process quality requirements and specifications	36%
Evaluation of technology application options	28%
Strategy definition	28%
Adaptation of business model	28%
Process development	28%
Technology portfolio management	28%
Absorption of technology knowledge	20%
Identify technology application options	20%
Industrial/manufacturing management	20%
People management	16%
Business model development	16%
Capability development & dynamic capability approach	16%
Exploration	8%
Exploitation	8%
Company's growth management	8%
Customer technological development	8%
Supplier technological development	8%
Industry's analysis related to innovation evolution	4%

the second level of grouping pattern, they are observed the groups spin-off development (3.1) and Product Development (3.2). The other groups are not so different, being grouped as shown in the point 3.3.

The next farther group was named Spin-Off development (3.1) and has comprised by attributes 'F_Spin-off Development' and 'F_Product Development in Spin-off'. The work of Goslish, Besterfield-Sacre and Shuman (2008) illustrates the group.

Farther as this last group was the group named product development (3.2). The focus in describing product development process was grouped with other commonly innovation-associated discussion contents. It was grouped in practices related to capture information from the environment. Others were more focused in internal capabilities, as 'Exploitation', the use of the obtained information; the creation of entrepreneurship culture to support this, the 'Corporative entrepreneurship management'; and the innovative culture to overcome rigidity and develop new capabilities for changing market, and new technologies, the 'Capability development & Dynamic Capability'. The document that illustrate this was Burgelman, Chirstensen and Wheelwright (2004), related to Strategy and Technology development management in established companies.

Analyzing in the third level, the group 3.3 can be subdivided into three other groups: related to Company's growth management (3.3.1), new venture development (3.3.2), and another with technology development (3.3.3).

The group named Company's Growth management (3.3.1), has clearly two subgroups. The method firstly grouped the attribute 'Company's Growth management' with the discussion related to the 'Business model development'. It indicates that

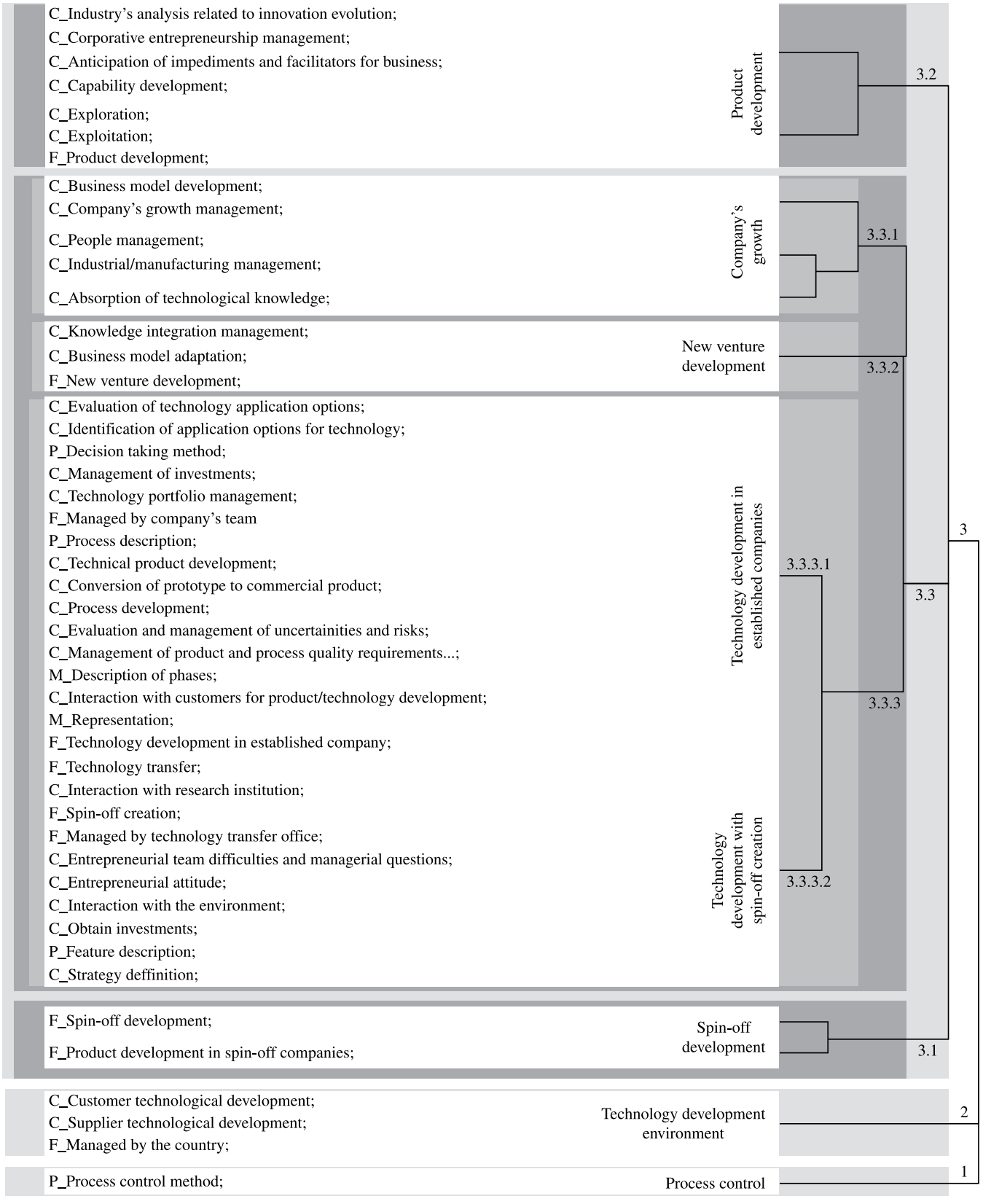

Figure 1. Summarized Dendogram representing the output of the hierarchical cluster analysis with average linkage method using Jaccard similarity measure.

the conjoint discussion of two themes was observed and business model development discussion is a possibility to study company growth management. The document that enables the illustration of this group is the work of Man, Lau and Chan (2002) that discusses the competitiveness of the small and medium firms, by the need of considering internal and external factors as constructs for developing business model, developing organizational capabilities.

The group named new venture development (3.3.2) presents a conjoint of attributes that is observed, for example, in the works of Andries and Debackere (2006). Andries and Debackere (2006) describe the adaptation process inside technology-based new ventures. In this process, the knowledge acquisition and integration is considered as essential.

And the last and broadest group was called technology development-related (3.3.3). For describing purposes, it was observed that this group can be divided in two groups, one comprised by attributes related to the technology development in established companies and another to the technology development with spin-off creation.

The first subgroup was considered as the group of the attributes presented by the documents and models that discuss technology development in established companies (3.3.3.1). In this reason, it is possible to describe those works as described as managed by company's team. It comprised the description of the process, usually presenting detail as description of phases, with some kind of representation. The practice-oriented focus could be observed, as the presentation of how-to instruction or decision taking method. Contents usually discussed in conjoint in documents that presented those attributes were related to the technical development phases or to the managerial activities. The works that presents the similarity of all those attributes were Creveling, Slutsky and Antis (2003) and Cooper (2006). Those works presented 'how to' instruction and methods for decision taking during the technology development in established company, considering all activities described previously.

The second subgroup was named technology development with spin-off creation (3.3.3.2). It was observed that the attribute focus on technology transfer, spin-off creation and vision of Technology transfer office managing this process was presented simultaneously in several documents. Other aspect was that the attribute of being described just a feature, not the all process description was very common. The document that illustrates the conjoint presence of these attributes is the work of Shane (2004).

4.3. Framework development

The further reading of the documents complemented the obtained clusters for framework development. Recent documents discussing technology and product development discusses absorptive capability, detailed as exploitation and exploration, for innovative products development (ATUAHENE-GIMA, 2005; LEVINTHAL; MARCH, 1993; MARCH; STOCK, 2006). Similar discussion can be observed for small and medium enterprises and entrepreneurship area (BIERLY; DALY, 2007; MAN, 2006). It also was observed the existence of a knowledge-based view (GRANT, 1996; ZAHRA; NIELSEN, 2002) on spin-off and technology development process description. The resulting framework is presented in Figure 2.

5. Discussion

This work enabled the identification of most discussed contents, and also the occurrence of the simultaneous discussion, indicating some relationship between the contents, focus or purpose.

5.1. Some detached discussion themes

Analysing the Table 3, it is possible to identify the more discussed contents. From the six more discussed contents, they are included the contents 'Interaction with Customers for product/technology development', and 'Interaction with the environment'. This reflects the state-of-the art of the both areas; the theme networking is widely discussed as an important aspect for efficient technology development process.

In this view, the spin-off is presented as a fruit of the individual and research institution interaction's evolution. It is trough that is by this interaction that occurs the learning and the development of the entrepreneur team and the spin-off company (DEGROOF; ROBERTS, 2004; CLARYSSE; HEIRMAN; DEGROOF, 2001; JOHANSSON; JACOB; HELLSTROM, 2005; POWERS; MCDOUGLALL, 2005; RASMUSSEN; BORCH, 2004; ROTHAERMEL; THURSBY, 2005; STEFFENSEN; ROGERS; KRISTEN, 1999; SCHOLTEN, 2006; NDONZUAU; PIRNAY; SURLEMONT, 2002). The interaction with the institution starts bidirectional and informal. With the evolution, this interaction reduces and the company must develop ties with the supplier, customers and others (JOHANSSON; JACOB; HELLSTROM, 2005).

The described above is suitable with the observed by the data obtained. The both areas discussed the theme networking, but the frequency is different. The

Table 4. Summary of documents that illustrate the similarity of networking related contents discussed by the documents with the focus in technology development in established companies and in spin-off creation.

	Spin-off Creation	**Established Companies**
Document amount	10	8
C_Interact_environment	100%	75%
C_Interact_customerProdTe	60%	75%
C_Interact_ResInst	90%	38%

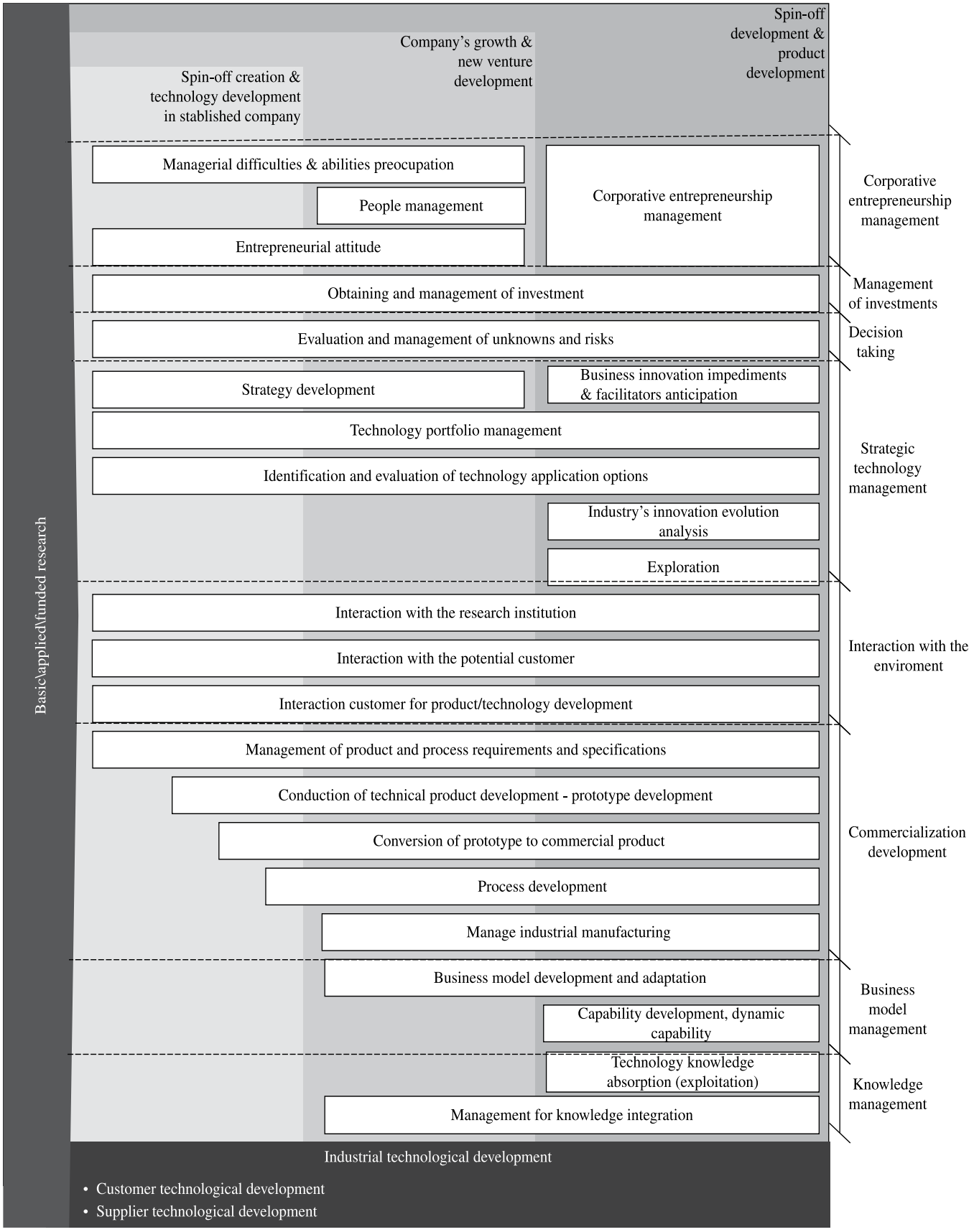

Figure 2. Spin-off company phases and its main discussed contents, with technology development phases

Table 5. Documents that illustrate the similarity of capabilities discussed by the documents with the focus in technology development in established companies and in spin-off creation.

	Main Focus	Technology Development in Established Companies	Spin-off Creation
Lee and Gaertner (1994)	Spin-off creation	53%	60%
Araújo et al. (2005)	Spin-off creation and development	59%	80%
Shane (2004)	Spin-off creation and development	76%	90%
Vohora et al. (2004)	Spin-off creation and development	82%	60%
Burgelman, Christensen and Wheelwright (2004)	Technology development in established companies	76%	50%

Table 4 summarizes the counting and it enables to illustrate the observed in the literature.

In the six more discussed contents group it is also observed the content 'Entrepreneur team difficulties - managerial questions' and 'Corporative entrepreneurship management'. In the following most-cited group, it is also observed 'Entrepreneurial attitude'. This emphasis in entrepreneurship is obvious because the Entrepreneurship area presented great contribution to the theme academic spin-off.

The management of the information capture and use is also detached. Some attributes with substantial frequency (more than 40 %) that denotes concern about which information is important were: Interaction with Customers for product/technology; Anticipation of impediments and facilitators for business innovation strategy; and Evaluation and management of uncertainties and risks.

The attributes that indicate concern about the information use can be the following: The integration of the knowledge, and Management of Product and process quality requirements and specifications. But those were less frequent than the information capture or networking-related ones.

So, it is observed that the discussion related to technology development process, in its majority, present more focus in macro and meso views. The more internal aspect is related to the meso level, as networking with costumer, supplier for information capture. The micro-level discussion, as how to structure for technology development process, is less observable.

5.2. Who conducts the technology development via spin-off development?

In the subject documents focus, it was observed documents describing academic spin-off creation as conducted by the Research Institution (SHANE, 2004; THORBURN, 2000; AUTIO, 1994; DEGROOF; ROBERTS, 2004; LOCKETT; WRIGHT, 2005; CLARYSSE; HEIRMAN; DEGROOF, 2001). There were also document describing the influence of the institutional innovation system maturity level in deciding if the environment is more favourable or not for the company's development (DEGROOF; ROBERTS, 2004; CLARYSSE; HEIRMAN; DEGROOF, 2001).

Independently the environment, the companies must not be just responsive, but proactive. Muegge et al. (2005), for example, emphasizes the importance of the planning and flexibility in uncertain environment.

Regarding the topic who conduct the process, some documents describes technology development as conducted by own company (SHANE, 2004; VOHORA; WRIGHT, LOCKETT, 2004; ZAHRA; DeVELDE; LARRAÑETA, 2007). The same can be observed in models describing the spin-off company creation as managed by the company (ARAÚJO, et al., 2005; DRUILHE; GARNSEY, 2004; VOHORA; WRIGHT; LOCKETT, 2004).

The obtained cluster (Figure 1) shows clearly that there are different foci related to the question who conducts the technology development management. And this is related to the main focus, in the manner that it is possible to infer that:

Proposition 1.The technology development via environmental approach describes the process as managed by the country or the Institution. Nevertheless, the technology development focus is view as a process managed by own company.

5.3. Practical application of documents for technology development process in spin-off company

Regarding the document detail level, documents presenting phase descriptions comprised 56% and those presenting graphical representation comprised 52%. Regarding the document purpose, the documents related to spin-off companies were essentially descriptive, presenting phases, activities, or some important element to be considered for the company development. The paper of Vohora, Wright and Lockett (2004) was presented as the wider model. This document presented description from the research to the product commercialization, with critical junctures emphasizing critical factors in phase transition points. The model of the Araújo et al. (2005) presented a focus on the decision-making process for the company creation, including business opportunity identification, technical and commercial viability.

It was not observed any document describing control or decision-taking methods to conduct the technology development process inside the spin-off company, as

observed for existing companies (COOPER, 2006; CREVELING; SLUTSKY; ANTIS, 2003; BURGELMAN; CHRISTENSEN; WHEELWRIGHT, 2004; AJAMIAN; KOEN, 2002). The document most related with this topic is from the investments area, the paper of Martins-Rodrígues (2003). It presented the discussion related to the spin-off company evaluation, in the sense that the venture capital company needs to evaluate this kind of company for profitability. Actually, the traditional investment methods are not sufficient for this situation, because spin-off is so dependent of intangible resources, as business model, and coordination team's abilities and personality (MARTINS-RODRÍGUEZ, 2003).

This can give an idea of how difficult is to evaluate the environment of this kind of companies and to take decisions. In the same manner, the decision-taking process inside the company is a hard task. Previous planning is defaulted by the low information availability. So, the discovery-driven planning methodology appears to be more adequate for technology development process, both in established company (McGRATH; MacMILLAN, 2004) and in a new venture, as academic spin-off in developing and creation phase.

5.4. Technology development in established company x academic spin-off

The conducted cluster analysis showed that the high frequency of the simultaneous discussion of attributes focus indicates that technology transfer process and academic spin-off creation process are not distinguishable, and viewed as managed by Technology Transfer Office. This focus is also not so distinguishable from other attributes, as the 'focus in technology development in established company', as presented in the Figure 1. Therefore it is possible to infer that documents describing the creation of spin-off companies commonly discuss the same capabilities of documents describing the technology development in established companies. To illustrate this affirmation, Table 5 shows that documents with in both focus discusses the capabilities of two sub-clusters.

The four documents have as main focus the creation of spin-off companies, but also discuss the majority of themes grouped in the cluster technology development in established companies. In the same way, the documents discussing as main focus the Technology Development in the Established companies, discusses great part of the contents of the spin-off creation cluster. This description enables the confirmation of described above:

Proposition 2. Documents discussing spin-off creation discusses commonly the same capabilities discussed by documents for technology development in established companies.

So, we can understand that the imputed importance of each main routines were not distinguishable among the Technology Development in Established Companies and the Spin-off Creation Process. In both are discussed as important: interaction with the environment, entrepreneurial attitude, obtaining and management of investments, decision making process (with risk and unknowns assessing), strategic technology management, interaction with the environment, commercialization development. As the company establishes as a new venture, it is needed a worry with business model development, management for knowledge integration, and needs to start a concern about people management. In the spin-off development stage, the focus is similar for product development process, over all already discussed capabilities, new ones will be developed: a corporative entrepreneurship management, instead of a simple worry about managerial difficulties and abilities, or entrepreneurial attitude; a routine to anticipate business innovation impediment and facilitators, assessing Industry's innovation evolution path, instead of simple strategy development; a routine to conduct exploration; routines to develop and adapt already existing capabilities, in other words, develop dynamic capabilities, instead of simple business model reactive adaptation; and routine for technology knowledge absorption (exploitation), more than knowledge integration.

Analyzing the summarized dendogram grouping pattern, it is observed that the new venture development and company's growth is so closed in their themes discussion as spin-off creation and technology development in established companies' related attributes. From the sampled documents, it seems that the attribute process control method is an approach so far from the other attributes groups as the attributes related to the discussion of the National Innovation System.

It is observed an enlargement of coverage in clustering pattern. The coverage of the spin-off in creation phase is obviously smaller than the following moments. Other capabilities must be developed for establishment as new venture, and must evolve including more capabilities to enable product development. The matching of the clustering pattern with the logical perception of coverage enlargement indicates that the conducted analysis was correct. So, the coverage enlargement was disposed in a framework, as presented.

It was observed that some works presented evolutionary approach in technology development process as evidenced by the frequency of the discussion content 'capability development and dynamic capability perspective' (see Figure 2). The company's growth management, specifically development and adaptation of capabilities and business model is a recent view for technology development process in established companies (BURGELMAN; CHRISTENSEN; WHEELWRIGHT, 2004). The similar discussion is observed

for development of the new technology-based companies (including academic spin-off) (ZAHRA; SAPIENZA; DAVIDSON, 2006; DRUILHE; GARNSEY, 2004; MAN; LAU; CHAN, 2002; VOHORA; WRIGHT, LOCKETT, 2004; ANDRIES; DEBACKERE, 2006).

In the similar way, the framework was elaborated intending to show the evolutionary view of the technology development process in academic spin-off company and, consequently the spin-off development, focusing on capabilities evolving pattern. The attributes grouping pattern was used to demonstrate the company's evolutionary pattern, designed in the concern of the most discussed capabilities for each moment.

The technology development process in academic spin-off and established companies presents similarities and differences. Despite the environment in which the technology development occurs (newly established or pre-existing company), for each invention has potentially several applications and different markets (SHANE, 2004; BURGELMAN; SAYLES, 2004). For each market and application, different capability (routine) configurations must be developed. This configuration of routines shapes the company's business model (CHESBROUGH; ROSENBLOON, 2002; MORRIS; SCHINDEHUTTE; ALLEN, 2005).

Proposition 3. From the capability development view of technology development process management, the initial capabilities needed to create the spin-off company are the same of the technology development in established companies. After the company must grow, enclosing other capabilities. The capabilities needed for product development management process are broader, and includes that announced before.

The presented contents can be understood as related to main routines (formal or informal) that the company must develop. These capabilities comprises from operational ones and managerial ones. The first group of capabilities aims to obtain the main objective – the conversion of technology in commercially viable products and services. The second group presents capabilities related to obtain more efficiency in this process, configuring the company to be more fitted to the environment.

6. Conclusion

This work analyzed 99 documents, works dated from 1994 to 2008, for identification of ideas of capabilities needed for technology development. Based on selected technology development related documents compared the most discussed capabilities in different kind of documents – technology development in established company, creation of spin-off company, development of spin-off company, development of new ventures, and new technology based product development process. Academic spin-off development documents and technology development documents, even not using an evolutionary organizations view's logic, were compiled, resulting in a descriptive model.

- The conducted review, associated with the analysis, allowed the description of these documents in this capabilities discussion, grouping them.
- The selected method content analysis associated with binary cluster analysis presented itself as efficient for the intended objectives.
  - The existing documents comparison allowed the identification of main question areas for capability identification in technology-based companies, even for creation, establishment as new venture, or development stage.
  - Main routines discussed as important and needed for technology development process viability and spin-off company development were identified.
  - The selected routines developed by the company comprise its capabilities and, those capabilities organized in a logic structure comprise the company's business model. This business model evolves and is changed by other decisions taken by the company (path dependency). The capability (routines) can be informal, detaching the importance of considering informal structures in company.
  - It was also observed that the decision-taking process for capability development is a hard task because information's low availability and high environmental risk and uncertainty in technology-based companies, especially when the technology is more innovative. This scenario also composes the need for business model change and evolution. For this reason, this document emphasizes specific capabilities: the company's grow management; knowledge integration management; and the interaction with the environment.
  - The need of specific capabilities in the both process – technology development in established company and spin-off creation - were not as distinguishable as the literature state-of-the art indicates.
  - The obtained framework shows that a discussion related to capability and its development can be adequate for new technology-based companies (including academic spin-off) development.

This paper demonstrated that especially when the technology is highly innovative, it is detached the idea of capability development and business model construction either in spin-off or established company. It agrees with literature showing the capability development promotion discussion as a tendency both for innovative technology

and product development and for new technology-based companies' development.

This work analyzed the question 'do the established companies and academic spin-off companies need different capabilities for Technology development process?' using secondary data, the literature available documents. In the aim of conducting this analysis, some guiding ideas of capabilities indications were listed. So, as future works, we suggest the conduction of this analysis using primary data, analysing the capabilities configuration in real technology-based companies in different development stages.

7. References

AJAMIAN, G. M.; KOEN, P. A. Technology stage-gate: a structured process for managing high-risk new technology projects. In: BELIVEAU, P.; GRIFFIN, T.; SOMERMEYER, S. **The PDMA toolbox for new product development**. New York: John Wiley & Sons, 2002. p. 267-295.

ALDRICH, H.; RUEF, M. Enterpreneurs and the emergence of new organizations. In: ALDRICH, H.; RUEF, M. **Organizations envolving**. Newbury Park: SAGE, 2006. p. 61-91.

ALDRICH, H.; RUEF, M. **Organizations Evolving**. Newbury Park: SAGE, 2006. v. 2.

ANDRIES, P.; DEBACKERE, K. Adaptation in new technology-based ventures: insights at the company level. **International Journal of Management Reviews**, v. 8, n. 2, p. 91-112, 2006.

applications guide. Chicago: SPSS, 1997.

ARAÚJO, M. H. et al. Spin-off acadêmico: criando riquezas a partir de conhecimento e pesquisa. **Química Nova**, v. 28, p. S26-S35, 2005.

ATUAHENE-GIMA, K. Resolving the capability-rigidity paradox in new product innovation. **Journal of Marketing**, v. 69, p. 61-83, 2005.

AUTIO, E. New, technology-based firms as agents of R&D and innovation: an empirical study. **Technovation**, v. 14, n. 4, p. 259-273, 1994.

BARNEY, J. B. Resource-based theories of competitive advantage: a ten-year perspective on the resource-based view. **Journal of Management**, v. 27, p. 643-650, 2001.

BELL, M.; PAVITT, K. The development of technological capabilities. In: HAQUE, I.; BELL, M. **Trade, technology and international competitiveness.** Washington, DC: World Bank Publications, 1995. p. 69-101.

BIERLY, P. E.; DALY P. S. Alternative knowledge strategies, competitive environment, and organizational performance in small manufacturing firms. **Entrepreneurship Theory and Practice**, v. 31, n. 4, p. 493-516, 2007.

BURGELMAN, R. A.; CHRISTENSEN, C. M.; WHEELWRIGHT, S. C.. **Strategic management of technology and innovation**. 4. ed. Columbus: McGraw-Hill Irwin, 2004.

BURGELMAN, R. A.; SAYLES, L. R.. Transforming invention into innovation: the conceptualization stage. In: BURGELMAN, R. A.; CHRISTENSEN, C. M.; WHEELWRIGHT, S. C. **Strategic management of technology and innovation**. Columbus: McGraw-Hill Irwin, 2004.

CHESBROUGH, H.; ROSENBLOON, R. S. The role of the business model in capturing value from innovation: evidence from Xerox Corporation's Technology spin-off companies. **Industrial and Corporate Change**, v. 11, n. 3, p. 529-555, 2002.

CLARYSSE, B.; HEIRMAN, A.; DEGROOF, J. J.. An institutional and resource-based exploration of growth patterns of research-based spin-offs in Europe. **STI Review**, v. 26, p. 75-96, 2001.

COOPER, R. G. Managing Technology Development Projects. **Research-Technology Management**, v. 47, n. 3, p. 23-31, 2006.

CREVELING, C. M.; SLUTSKY, J. L.; ANTIS, D. Jr. **Design for Six Sigma:** in technology and product development. New Jersey: Pearson Education, 2003.

DEGROOF, J. J.; ROBERTS, E. B.. Overcoming weak entrepreneurial infrastructures for academic spin-off ventures. **Journal of Technology Transfer**, v. 29, p. 327-352, 2004.

DRUILHE, C.; GARNSEY, E.. Do academic spin-outs differ and does it matter? **Journal of Technology Transfer**, v. 29, n. 3-4, p. 269-285, 2004.

DURAND, R. **Organizational evolution and strategic management**. Newbury Park: SAGE, 2006.

GOLISH, B. L.; BESTERFIELD-SACRE, M. E.; SHUMAN, L. J.. Comparing academic and corporate technology development processes. **Journal of Product Innovation Management**, v. 25, p. 47-62, 2008.

GRANT, R. M. Toward a knowledge-based theory of the firm. **Strategic Management Journal**, v. 17, p. 109-122, 1996.

HAIR, J. F. Jr. et al. **Multivariate data analysis**. 5. ed. New Jersey: Prentice Hall, 1998.

HELFAT, C. E.; PETERAF, M. A. The dynamic resource-based view: capability lifecycles. **Strategic Management Journal**, v. 24, p. 997-1010, 2003.

IANSITI, M. Technology development and integration: an empirical study of the interaction between applied science and product development. **IEEE Transactions on Engineering management**, v. 42, n. 3, p. 259-269, 1995.

JOHANSSON, M.; JACOB, M.; HELLSTRÖM, T. The strength of strong ties: university spin-offs and the significance of historical relations. **Journal of Technology Transfer**, v. 30, p. 271-286, 2005.

KRIPPENDORFF, K. **Content analysis**: an introduction to its methodology. Newbury Park: SAGE, 1980.

LEE, Y.; GAERTNER, R. Technology transfer from university to industry: a large-scale experiment with technology development and commercialization. **Policy Studies Journal**, v. 22, n. 2, p. 384-399, 1994.

LEVINTHAL, D. A.; MARCH, J. G.. The myopia of learning. **Strategic Management Journal**, v. 14, p. 95-112, 1993.

LOCKETT, A.; WRIGHT, M. Resources, capabilities, risk capital and the creation of university spin-out companies. **Research Policy**, v. 34, p. 1043-1057, 2005.

MAN, T. W. Y. Exploring the behavioural patterns of entrepreneurial learning: A competency approach. **Education + Training**, v. 48, n. 5, p. 309-321, 2006.

MAN, T. W. Y.; LAU, T.; CHAN, K. F.. The competitiveness of small and medium enterprises: a conceptualization with focus on entrepreneurial competencies. **Journal of Business Venturing**, v. 17, p. 123-142, 2002.

MARCH, S. J.; STOCK, G. N.. Creating dynamic capability: the role of intertemporal integration, knowledge retention, and Interpretation. **Journal of Product Innovation Management**, v. 23, p. 422-436, 2006.

MARKHAN, S. K. Moving technologies from lab to market. **Research - Technology Management**, v. 45, n. 6, p. 31-42, 2002.

MARKMAN, G. D. et al. Inovation speed: transferring university technology to market. **Research Policy**, v. 34, p. 1058-1075, 2005.

MARTINS-RODRÍGUEZ, B, M. A new insight into the valuation of start-ups: bridging the intellectual capital gap in venture capital appraisals. **Electronic Journal on Knowledge Management**, v. 1, n. 2, p. 125-138, 2003.

MATHEWS, J. A. Strategizing is carried out by pensrosean, resource-based firms. In: MATHEWS, J. A. **Strategizing, disequilibrium, and profit.** Palo Alto: Stanford University Press, 2006. p. 73-97.

McGRATH, R. G.; MacMILLAN, I. C. Discovery-driven planning. In: BURGELMAN, R. A.; CHRISTENSEN, C. M.; WHEELWRIGHT, S. C. **Strategic management of technology and innovation**. Columbus: McGraw-Hill Irwin, 2004. p. 838-846.

MORRIS, M.; SCHINDEHUTTE, M.; ALLEN, J. The entrepreneur's business model: toward a unified perspective. **Journal of Business Research**, v. 58, p. 726-735, 2005.

MUEGGE, S.; SHARMA, M.; KUMAR, U. An exploratory study of new product development at small university spin-offs. Engineering Management Conference, 2005. **Proceedings. IEE International,** v.2, p. 626-631, 2005.

NDONZUAU, F. N.; PIRNAY, F.; SURLEMONT, B. A stage model of academic spin-off creation. **Technovation**, v. 22, n. 5, 281-289, 2002.

NELSON, R. R.; WINTER, S. G. **An evolutionary theory of economic change**. Massachusetts: Harvard University Press, 1982.

NELSON, R. R.; WINTER, S. G. **Uma teoria evolucionária da mudança econômica.** Campinas: Editora UNICAMP, 2005.

POWERS, J. B.; MCDOUGLALL, P. P. University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship. **Journal of Business Venturing**, v. 20, n. 3, p. 291-311, 2005.

PRAHALAD, C. K.; HAMEL, G. The core competence of the corporation. **Harvard Business Review**, v. 68, n. 3, p. 79-91, 1990.

QUIRK, T. Science in the service of the nation state. **Policy**, v. 21, n. 3, p. 32-39, 2005.

RADOSEVICH, R. A model for entrepreneurial spin-offs from public technology sources. **International Journal of Technology Management**, v. 10, n. 7-8, p. 879-893, 1995.

RASMUSSEN, E.; BORCH, O. J.. University resources facilitating strategic entrepreneurship. In: BI-ANNUAL EUROPEAN SUMMER UNIVERSITY, 2., Twente, 2004. **Anais…** Cidade: University of Twente, 2004.

ROMESBURG, C. **Cluster analysis for researchers**. North Carolina: Lulu Press, 2004.

ROTHAERMEL, F. T.; THURSBY, M.. Incubator firm failure or graduation? The role of university linkages. **Research Policy**, v. 34, p. 1076-1090, 2005.

SCHOLTEN, V. E. **The early growth of academic spin-offs**: factors invluencing the early growth of dutch spin-offs in the life sciences, ict and consulting. 2006. 216 f. Tese (Doutorado) - Whageningen University and Researchcentrum, Rotterdam, 2006.

SHANE, S. A. **Academic entrepreneurship**: University Spinoffs and Wealth Creation. Cheltenham: Edward Elgar Publishing, 2004.

STEFFENSEN, M.; ROGERS, E. M; KRISTEN, S. Spin-Offs from research centers at a research university. **Journal of Business Venturing**, v. 15, p. 93-111, 1999.

STOELHORST, J. W. Why is management not an evolutionary science? Evolutionary theory in strategy and organization.

Journal of Management Studies, v. 45, n. 5, p. 1008-1023, 2008.

TEECE, D. J.; PISANO, G.; SHUEN, A. Dybamic capabilities and strategic management. **Strategic Management Journal**, v. 18, n. 7, p. 509-533, 1997.

THE SOCIETY FOR PROTECTIVE COATINGS – SSPC. SPSS. **Base 7.5:**

THORBURN, L. Knowledge management, research spinoffs and commercialisation of R&D in Australia. **Asia Pacific Journal of Management**, v. 17, p. 257-275, 2000.

UTTERBACK, J. M. Product Innovation as a Creative Force. In: UTTERBACK, J. M. **Mastering the dynamics of innovation:** how companies can seize opportunities in the face of technological change. Cambridge: Harvard Business Press, 1994. p. 57-78.

VOHORA, A.; WRIGHT, M.; LOCKETT, A. Critical junctures in the development of university high-tech spinout companies. **Research Policy**, v. 33, p. 147 -175, 2004.

WINTER, S. G. Understanding dynamic capabilities. **Strategic Management Journal**, v. 24, p. 991-995, 2003.

ZAHRA, S. A.; NIELSEN, A. P.. Sources of capabilities, integration and technology commercialization. **Strategic Management Journal**, v. 23, p. 377-398, 2002.

ZAHRA, S. A.; SAPIENZA, H. J.; DAVIDSON, P. Entrepreneurship and dynamic capabilities: a review, model and research agenda. **Journal of Management Studies**, v. 43, n. 4, p. 917-955, 2006.

ZAHRA, S. A.; van deVELDE, E.; LARRAÑETA, B. Knowledge conversion capability and the performance of corporate and university spin-offs. **Industrial and Corporate Change**, v. 16, n. 4, p. 569-608, 2007.